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13. ABSTRACT (Maximum 200 words)

This research has focused on use of a radio-frequency single-electron transistor (RF-SET) to detect the motion of individual electrons in nanostructures such as quantum dots (QDs). During the course of this research we have developed strongly coupled RF-SET/QD system and used them to detect individual electron tunneling events on the dot in a time scale as short as 1 μs. We have also studied the effects of changes in junction resistance on RF-SET operation, and by using reduced junction resistances have developed RF-SETs with improved sensitivity and linearity. We are currently extending these techniques to double quantum dot (DQD) systems, which we intend to use to measure the frequency-resolved backaction of the RF-SET. Finally, we are investigating the use of microwave impedance matching techniques to optimize the performance of our RF-SETs and minimize the time required for detection of individual electrons.

14. SUBJECT TERMS
Quantum dot, single electron transistor, microwave, radio frequency, nanostructure

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Enclosure 1

Final Progress Report
Investigation of High-Frequency Charge Dynamics in Nanoscale Structures

The purpose of this research was to develop techniques for detection of the motion of individual electrons on very short time scales (about 1 μs). This was to be accomplished by fabrication and operation of a fast and sensitive electrometer, the radio-frequency single electron transistor (RF-SET). By coupling the RF-SET to a semiconductor-based nanostructure such as a quantum dot (QD), we planned to develop a system capable of rapidly detecting the motion of single electrons.

We have succeeded in the above goals, procuding a strongly coupled RF-SET/QD system that allowed detection of individual electron tunneling events in a time scale as short as 1 μs. In addition, we have made significant progress in developing techinques for improved operation of the RF-SET, by means of reducing its junction resistance, thereby improving its impedance to our microwave circuitry. This reduction in junction resistance brings the added benefit of improved linearity as well. Finally, we have extended these charge detection techniques to more complex nanostructures such as double quantum dots (DQDs). We are currently in the process of using a DQD to make frequency-resolved measurements of the RF-SET backaction. Finally, we are in the process of developing on-chip impedance matching networks that should significantly increase the operating bandwidth of the RF-SET.

- Peer Reviewed Publications

  1. "Real-time detection of electron tunneling in a quantum dot," W. Lu, Z. Ji, L. N. Pfeiffer, K. W. West and A. J. Rimberg, Nature **423**, 422 (2003).
  2. "Sensitivity and linearity of superconducting radio-frequency single-electron transistors: Effects of quantum charge fluctuations," M. Thalakulam, Z. Ji, and A. J. Rimberg, Phys. Rev. Lett. **93**, 066804 (2004).

- Conference Proceedings

  1. "Real-time electron counting in semiconductor nanostructures," A. J. Rimberg, M. Thalakulam, W. Lu, Z. Ji, L. N. Pfeiffer and K. W. West, to appear in the proceedings of the SPIE.

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